## CLAIMS

What is claimed is:

1. A process for forming a refractory metal silicide stack with a diffusion barrier material nitride cover layer, comprising:

depositing a layer of a refractory metal on a production silicon surface layer in the presence of nitrogen, the production silicon surface layer being on a semiconductor substrate;

annealing the layer of the refractory metal in the presence of nitrogen to form a layer of a silicide of the refractory metal;

depositing multiple layers of a diffusion barrier material on a test semiconductor substrate in an environment of varying nitrogen content;

determining the barrier material deposition rate as a function of nitrogen content, such that:

the function is monotonically decreasing at least in one interval;

the interval includes a first section and a second section, with the first and second sections having a negative slope; and

the first section is connected, as the nitrogen content increases, to the second section at a transition region, the second section having a more negative slope, and the transition region comprising an optimum gaseous nitrogen content operating concentration;

sputtering a layer of the diffusion barrier material over the layer of the silicide of the refractory metal in an environment having approximately 15% of the optimum gaseous nitrogen content operating concentration, wherein the

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diffusion barrier material includes a material selected from the group consisting of tungsten alloys of Group III and Group IV early transition metals, Mo alloys of Group III and Group IV early transition metals, and mixtures thereof; and

growing nitride grains of the diffusion barrier material in the layer of the diffusion barrier material in an environment having a nitrogen content to form a layer of a nitride of the diffusion barrier material, wherein the nitride grains of the diffusion barrier material are approximately of equal size.

2. The process as recited in claim 1, wherein the production silicon surface layer comprises polysilicon.

3. The process as recited in claim 2, further comprising forming a nitridation on the production silicon surface layer.

4. The process as recited in claim 3, wherein forming the nitridation on the production silicon surface layer comprises implanting nitrogen into the production silicon surface layer.

5. The process as recited in claim 1, further comprising implanting phosphorous into the production silicon surface layer.

6. The process as recited in claim 1, wherein the layer of the diffusion barrier material is sputtered at a deposition rate of not less than about 400 Angstroms per minute.

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7. The process as recited in claim 6, wherein growing nitride grains of the diffusion barrier material in the layer of the diffusion barrier material comprises a second anneal, the process further comprising, prior to the second anneal and after annealing the layer of the refractory metal, stripping the refractory metal that is unreacted from the layer of the silicide of the refractory metal.

8. The process as recited in claim 1, wherein the point transition region comprises the point where the slope has the greatest rate of change.

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9. The process as recited in claim 1, wherein sputtering the layer of the diffusion barrier material over the layer of the silicide of the refractory metal is conducted in an environment within a range of about 3% of the optimum gaseous nitrogen content operating concentration.

10. The process as recited in claim 1, wherein the diffusion barrier material includes a material selected from the group consisting of $Sc_yM_z$, $Zr_yM_z$, $Zr_vSc_yM_z$, $Zr_vNb_yM_z$, $Zr_uSc_vNb_yM_z$, $Nb_yM_z$, $Nb_vSc_yM_z$, $Ti_yM_z$, $Ti_vSc_yM_z$, $Ti_vNb_yM_z$, $Ti_vZr_yM_z$, and mixtures thereof, where M is one of tungsten and molybdenum.

11. The process as recited in claim 1, wherein the grains of the nitride of the diffusion barrier material grown in the layer of the diffusion barrier material have a diameter in a range from about 1000 Angstroms to about 2000 Angstroms and have a crystalline structure.

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12. The process as recited in claim 1, wherein:

growing grains of the nitride of the diffusion barrier material comprises heating the layer of the diffusion barrier material in an environment comprising a gaseous nitrogen content;

growing grains of the nitride of the diffusion barrier material further comprises heating the layer of the diffusion barrier material at a temperature up to about 850°C for a time of up to about 30 minutes in the environment comprising a gaseous nitrogen content; and

there is substantially no out diffusion of nitrogen from the layer of the nitride of the diffusion barrier material.

13. The process as recited in claim 1, wherein:

growing grains of the nitride of the diffusion barrier material comprises heating the layer of the diffusion barrier material in an environment comprising a gaseous nitrogen content;

growing grains of the nitride of the diffusion barrier material comprises heating the layer of the diffusion barrier material with a rapid thermal nitridization at a temperature up to about 1000°C for a time of up to about 20 seconds in the environment comprising a gaseous nitrogen content; and

there is substantially no out diffusion of nitrogen from the layer of the nitride of the diffusion barrier material.

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14. The process as recited in claim 1, wherein nuclei of the nitride of the diffusion barrier material have a diameter in a range from about 30 Angstroms to about 50 Angstroms.

15. The process as recited in claim 1, wherein the layer of the nitride of the diffusion barrier material has a peak-to-valley roughness of less than about ten percent of the thickness thereof.

16. The process as recited in claim 1, wherein determining the barrier material deposition rate as a function of nitrogen content is performed by plotting the deposition rate of the diffusion barrier material as a function of the varying nitrogen content.

17. The process as recited in claim 1, wherein the optimum gaseous nitrogen content operating concentration is such that nitride nuclei of the diffusion barrier material are uniformly dispersed throughout the sputter layer of the diffusion barrier material, and there is substantially no grain growth of a nitride of the diffusion barrier material in the layer of the diffusion barrier material while sputtering the layer of the diffusion barrier material on the test semiconductor substrate.

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18. A process for forming a refractory metal silicide stack with a diffusion barrier material nitride cover layer, the process comprising:

depositing multiple layers of a diffusion barrier material on a test polysilicon surface layer in an environment of varying gaseous nitrogen content;

determining the barrier material deposition rate as a function of nitrogen content, such that:

the function is monotonically decreasing at least in one interval;

the interval includes a first section and a second section, with the first and second sections having a negative slope; and

the first section is connected, as the nitrogen content increases, to the second section at a transition region, the second section having a more negative slope, and the transition region comprising an optimum gaseous nitrogen content operating concentration, wherein at such optimum gaseous nitrogen content operating concentration nitride nuclei of the diffusion barrier material are uniformly dispersed throughout a sputtered layer of the diffusion barrier material, and there is substantially no diffusion barrier material nitride grain growth in the sputtered layer of the diffusion barrier material while sputtering the layer of the diffusion barrier material onto the test polysilicon surface layer;

selecting a first nitrogen content to correspond to within approximately 3% of the optimum gaseous nitrogen content operating concentration;

forming a nitridation on a polysilicon surface layer located on a semiconductor substrate by implanting nitrogen into the polysilicon surface layer;

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depositing a layer of a refractory metal on a production polysilicon surface layer in an environment of a carrier gas and gaseous nitrogen;

annealing the layer of the refractory metal in an environment of gaseous nitrogen to form a layer of a silicide of the refractory metal;

depositing a layer of the diffusion barrier material on the layer of the silicide of the refractory metal in an environment comprising an inert gas and the first nitrogen content, wherein there is between about $4 \times 10^8$ to about $4 \times 10^{15}$ nitride nuclei of the diffusion barrier material per $cm^2$ of the diffusion barrier material, and wherein the diffusion barrier material comprises a material selected from the group consisting of tungsten alloys of Group III and Group IV early transition metals, Mo alloys of Group III and Group IV early transition metals, and mixtures thereof; and

growing nitride grains of the diffusion barrier material in the layer of the diffusion barrier material in an environment of gaseous nitrogen at a temperature of between about 400°C and about 700°C to form a layer of a nitride of the diffusion barrier material.

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19. The process as recited in claim 18, wherein nitrogen is implanted into the polysilicon surface layer.

20. The process as recited in claim 18, wherein:

the layer of the diffusion barrier material is deposited at a deposition rate of not less than about 400 Angstroms per minute;

growing nitride grains of the diffusion barrier material in the layer of the diffusion barrier material forms a layer of a nitride of the diffusion barrier material having a peak-to-valley roughness of less than about ten percent of the thickness thereof; and

the nitride grains of the diffusion barrier material have a diameter in a range from about 1000 Angstroms to about 2000 Angstroms and have a crystalline structure.

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